

Field Evaluation of Vaisala Air Quality Transmitter AQT410 v.1.15



Background

- From 3/06/2018 to 5/03/2018, three **Vaisala AQT410 v.1.15** sensors were deployed in Rubidoux and were run side-by-side SCAQMD Federal Reference Method (FRM) and Federal Equivalent Method (FEM) instruments measuring the same pollutants
- Vaisala AQT410 v.1.15 (3 units tested):
 - Gaseous sensor (**electrochemical gas sensor; non-FRM/FEM**)
 - Each unit measures NO₂ (ppm), SO₂ (ppm), CO (ppm), Ozone (ppm), ambient air temperature (degree F), relative humidity (%), and pressure (mbar)
 - **Unit cost: ~\$3,700**
 - Time resolution: 1-min
 - Units IDs:
 - 0006
 - 0001
 - 0002
- SCAQMD FRM/FEM instruments:
 - CO instrument; **FRM, cost: ~\$10,000**
 - Time resolution: 1-min
 - NO_x instrument; **FRM, cost: ~\$11,000**
 - Time resolution: 1-min
 - O₃ instrument; **FEM, cost: ~\$7,000**
 - Time resolution: 1-min
 - SO₂ instrument; **FEM, cost: ~\$11,000**
 - Time resolution: 1-min
 - Meteorological station (temperature, relative humidity, and pressure); **cost: ~\$5,000**
 - Time resolution: 1-min



Differences between Vaisala AQT410 v.1.11 and v.1.15

Vaisala AQT410 v.1.11 had previously been evaluated in the field from 7/14/2017 to 8/22/2017 ([Vaisala AQT410 Field Evaluation Report](#))

- Hardware remains the same for both Vaisala AQT410 v.1.11 and v.1.15

Key firmware updates from v.1.11 to v.1.15

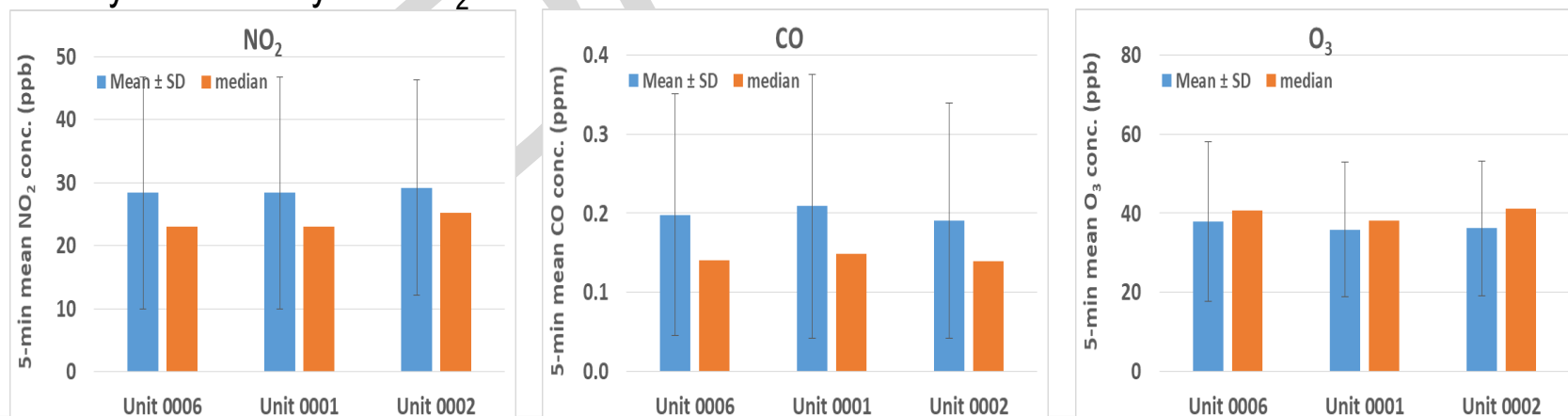
- Calibration parameters updated to new calibration system for baseline compensation of the gas measurements
- Instrument learning period increased based on tests at high concentrations
- Bug fix for temperature compensation of gas measurements at high ambient temperatures
- Reliability of use improved for the device and Modbus communications

Data validation & recovery

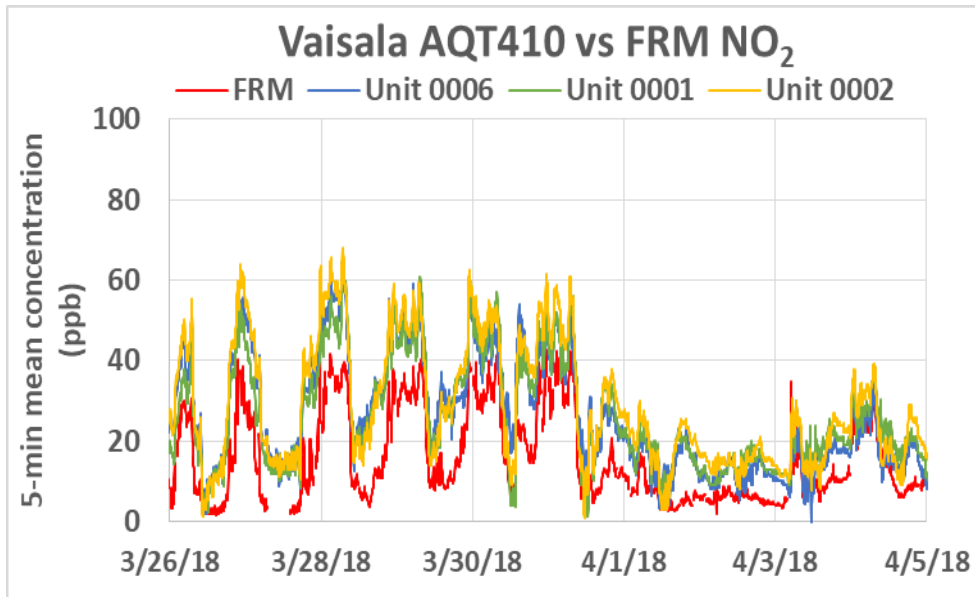
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values, and invalid data-points were eliminated from the data-set)
- Data recovery was over 96% for all units/pollutants tested, except for ozone, which had a data recovery of >85%.

Vaisala AQT410; intra-model variability

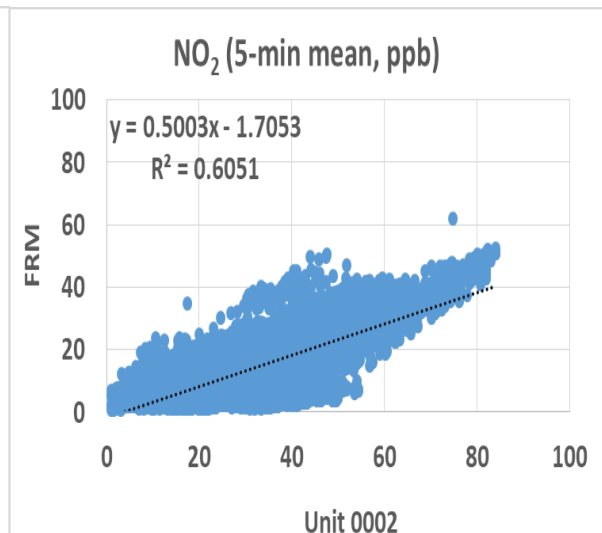
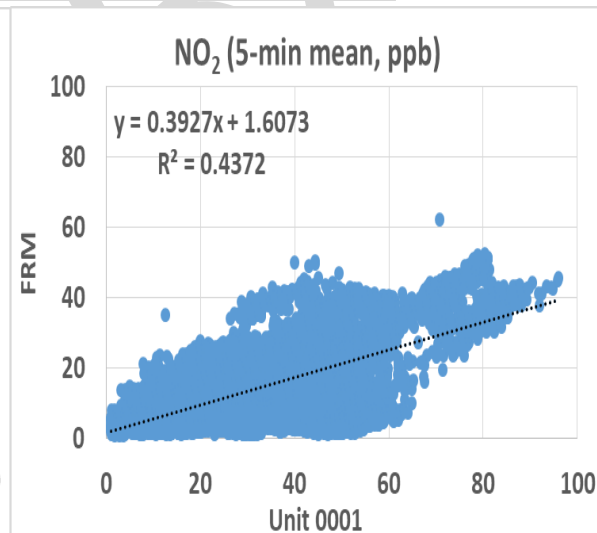
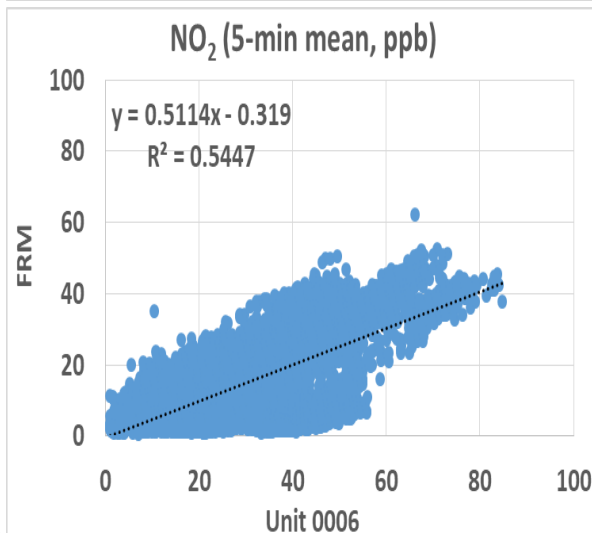
- Relatively low intra-model variability was observed for CO and Ozone, from all Vaisala AQT410 sensors (5.4% and 9.5%, respectively)
- NO₂ levels showed a relatively higher variation among the tested AQT410 sensors (11.6%)
- SO₂ evaluation was not included in this report due to its concentrations being too low to be reliably detected by the SO₂ FEM instrument



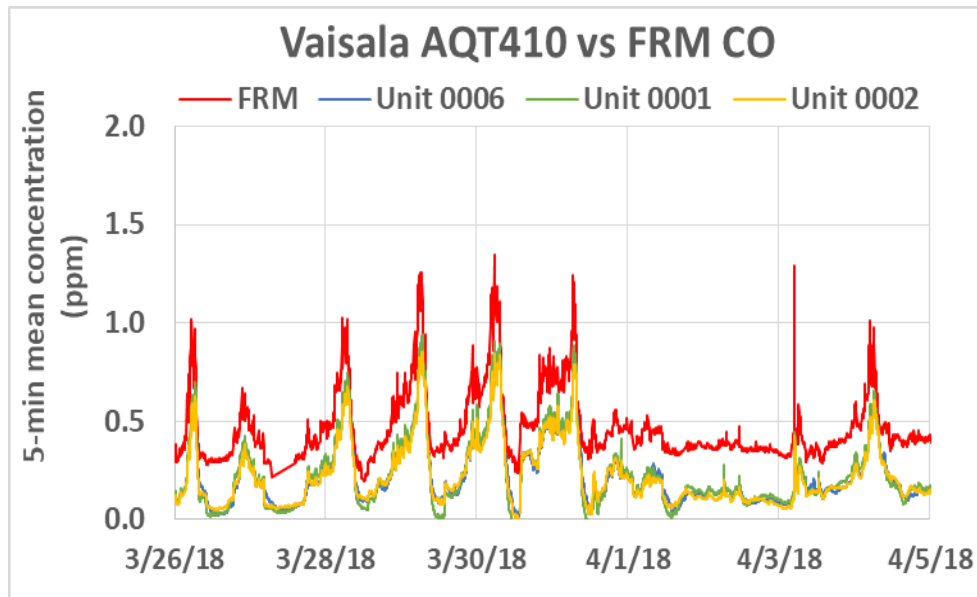
Vaisala AQT410 vs FRM (NO₂; 5-min mean)



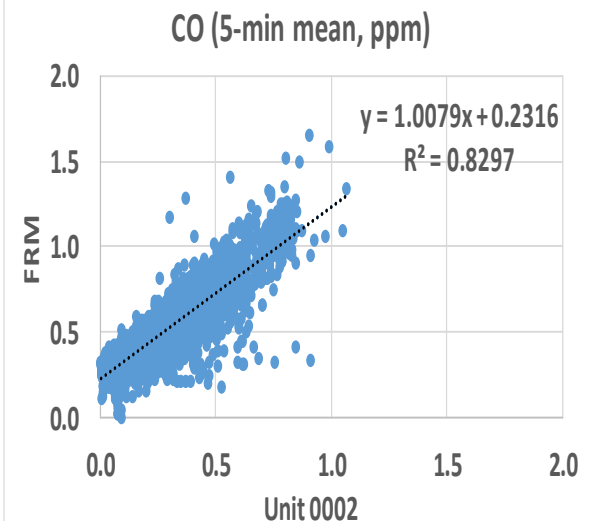
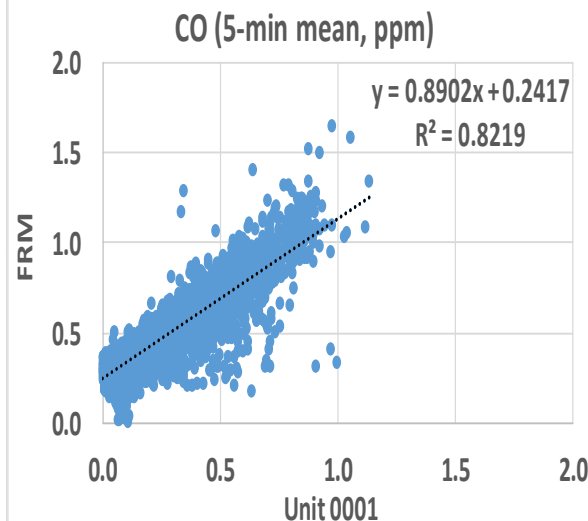
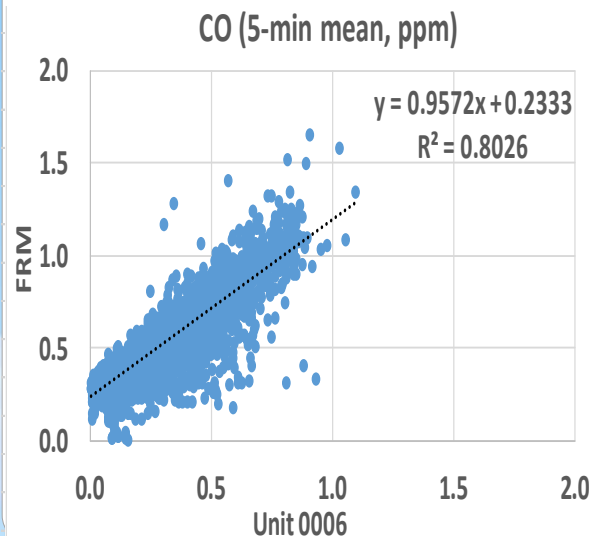
- NO₂ measurements from all three AQT410 sensors correlate moderately with the corresponding FRM data ($0.43 < R^2 < 0.61$)
- Overall, the AQT410 sensors overestimate NO₂ concentrations measured by the FRM instrument



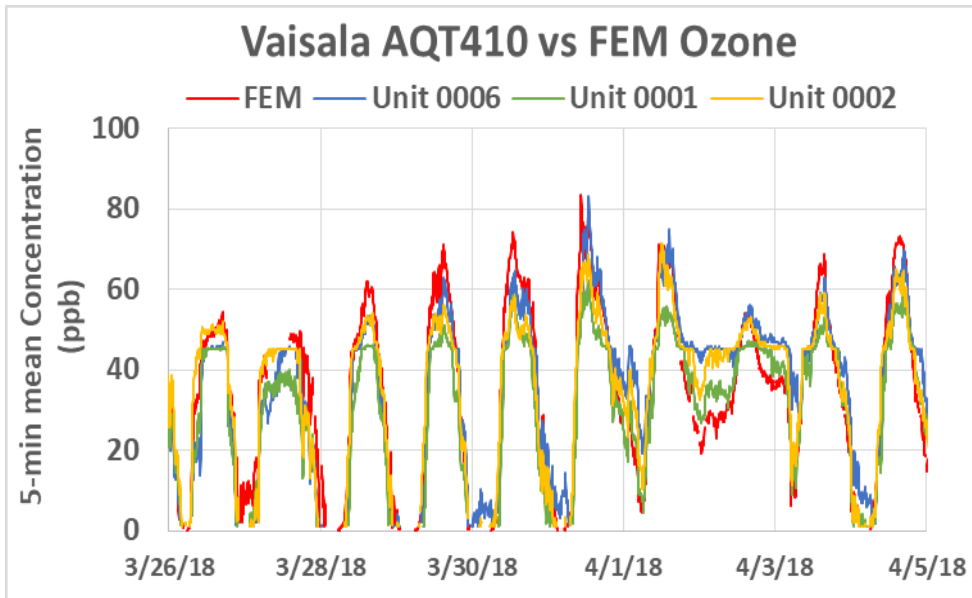
Vaisala AQT410 vs FRM (CO; 5-min mean)



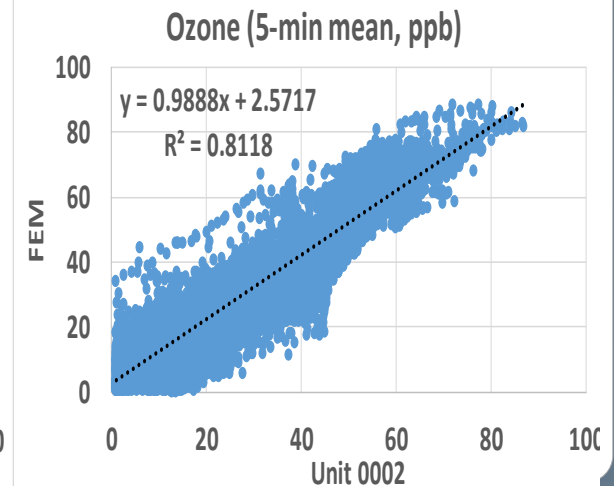
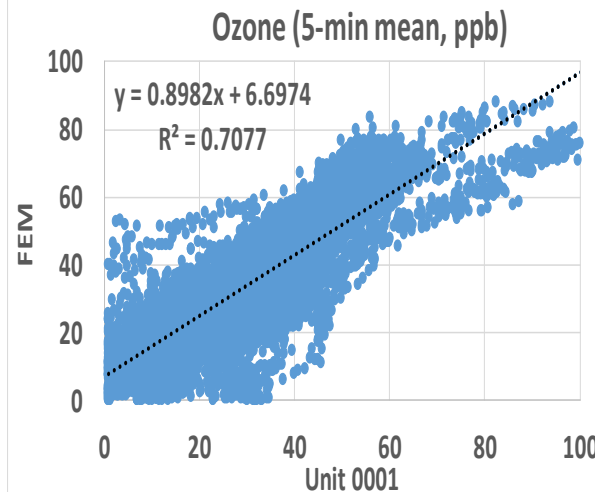
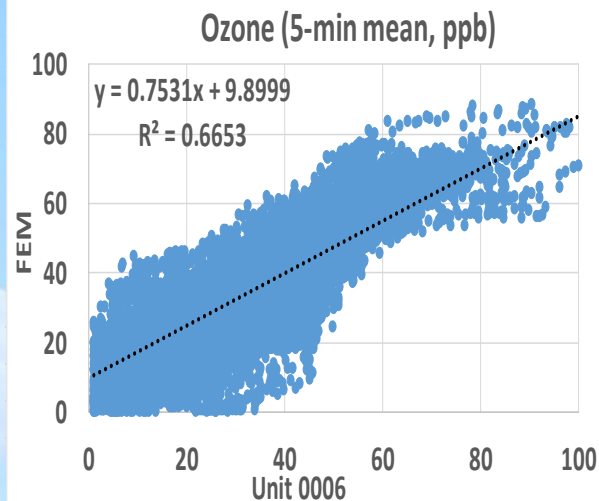
- AQT410 sensors show very good correlations with the corresponding FRM CO data ($0.80 < R^2 < 0.83$)
- AQT410 sensors seem to track well the diurnal CO variation recorded by the FRM instrument



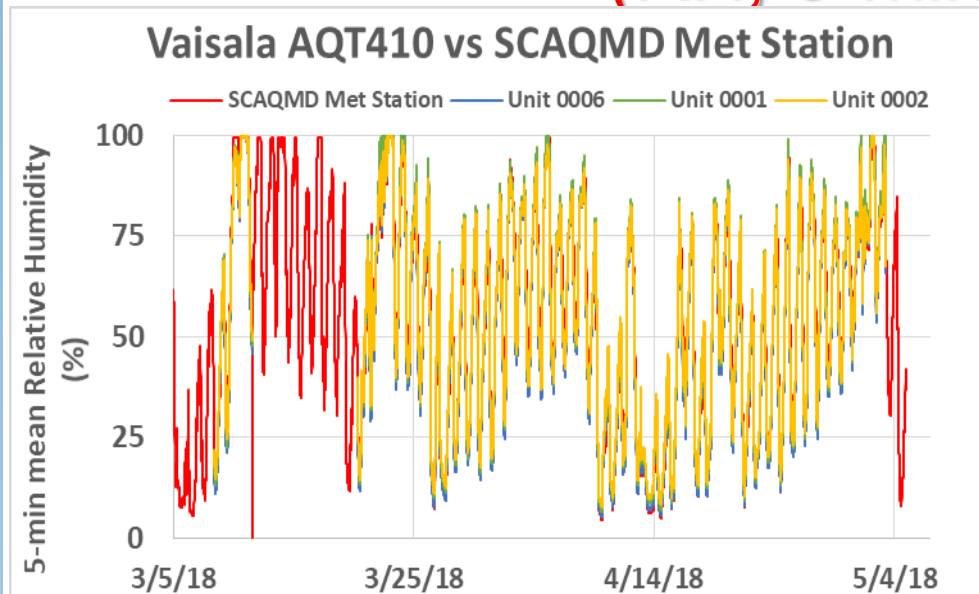
Vaisala AQT410 vs FEM (ozone; 5-min mean)



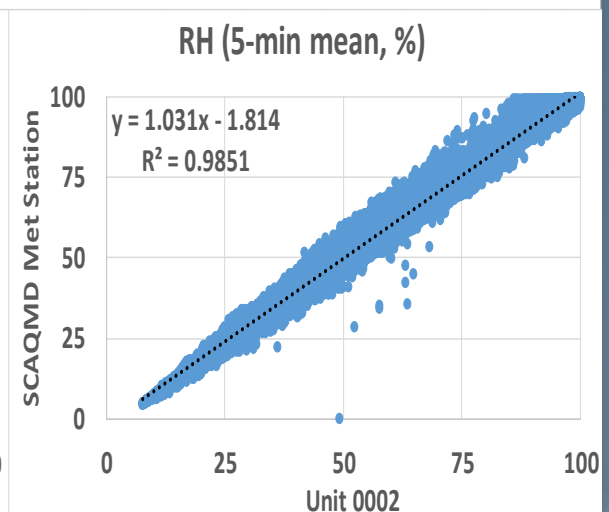
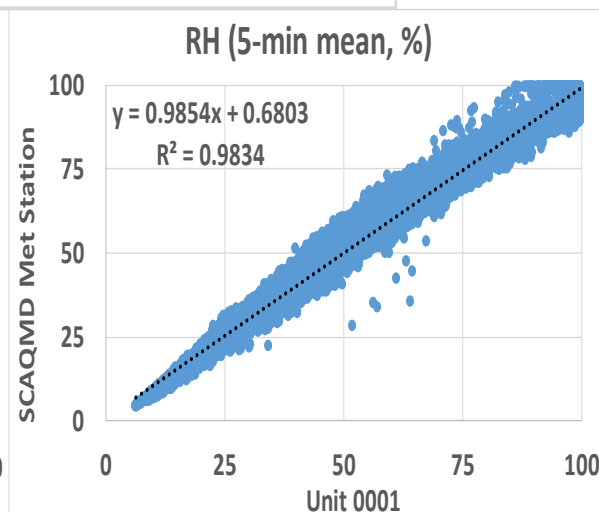
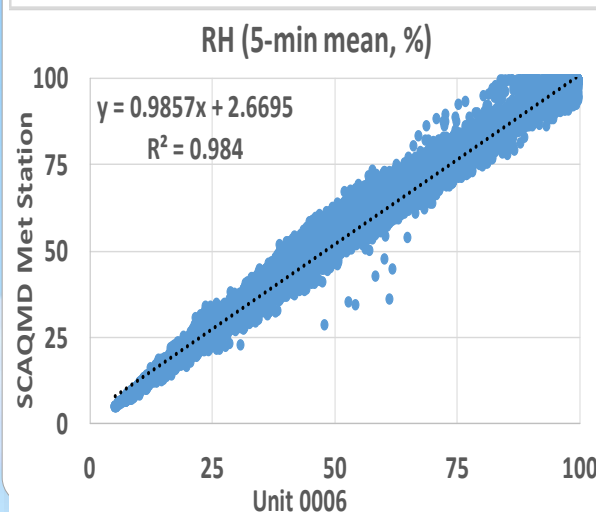
- AQT410 ozone measurements show good correlations with the corresponding FEM data ($0.66 < R^2 < 0.82$)
- AQT410 sensors seem to track well the diurnal ozone variations recorded by the FEM instrument



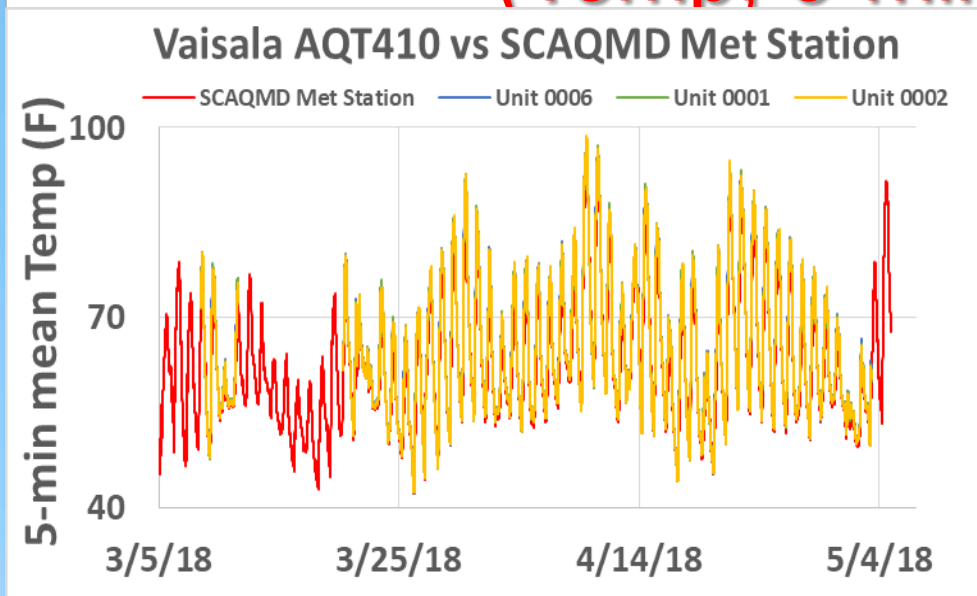
Vaisala AQT410 vs SCAQMD Met Station (RH; 5-min mean)



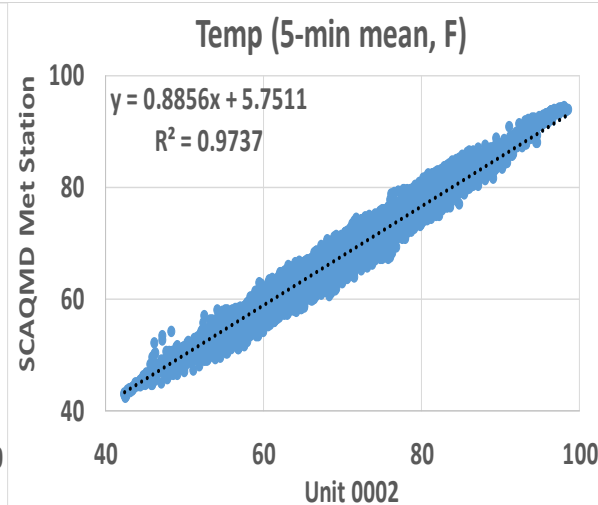
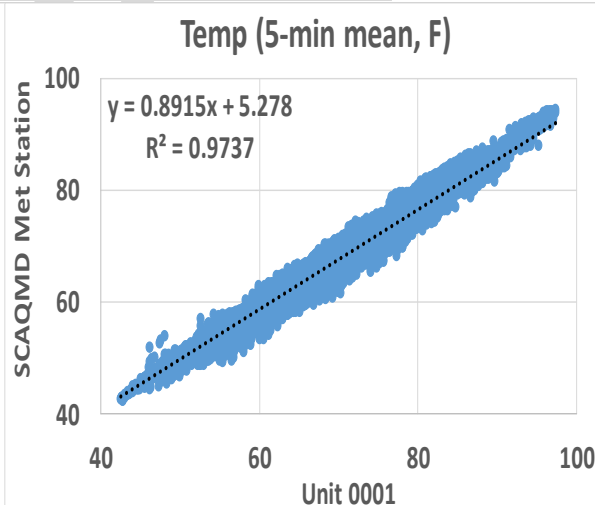
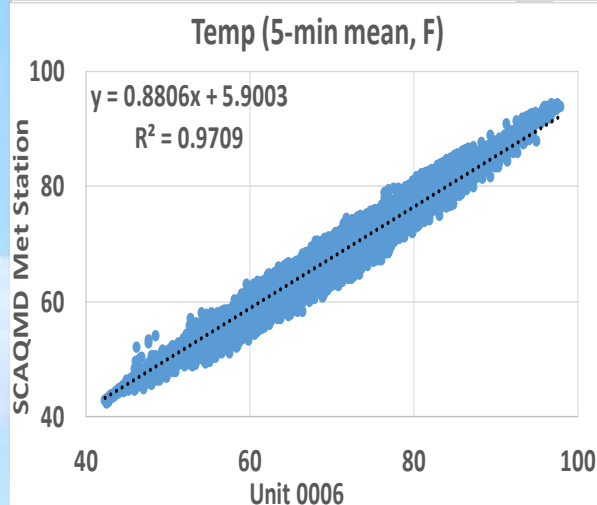
- AQT410 Relative Humidity measurements correlate very well with the corresponding FRM data ($R^2 > 0.98$)
- AQT410 sensors seem to track well the diurnal RH variations recorded by the SCAQMD Met station sensor



Vaisala AQT410 vs SCAQMD Met Station (Temp; 5-min mean)

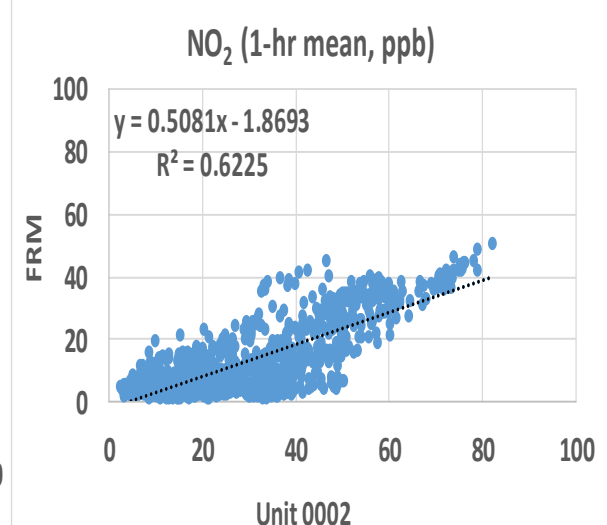
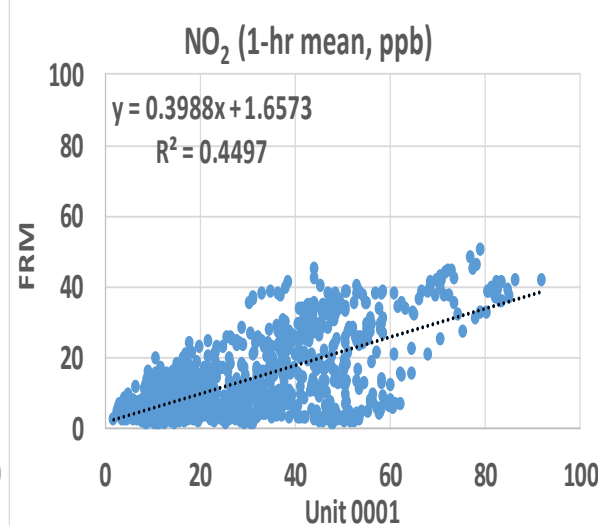
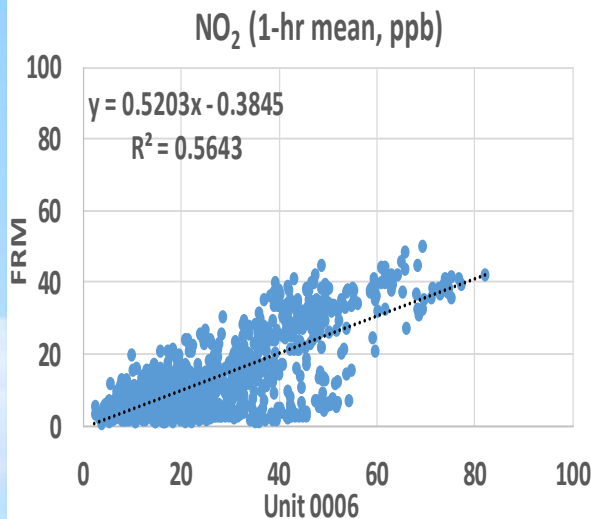
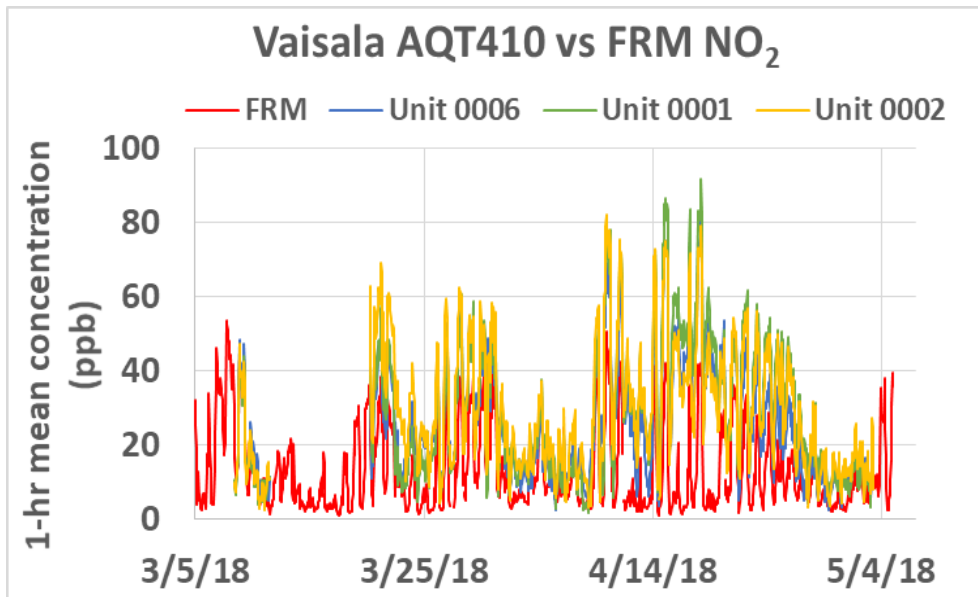


- Temperature measurements from all three AQT410 sensors correlate very well with the corresponding SCAQMD Met Station data ($R^2 > 0.97$), but they slightly overestimate the temperature measured by the SCAQMD Met Station sensors
- AQT410 sensors seem to track well the diurnal Temp variations recorded by the SCAQMD Met station sensor

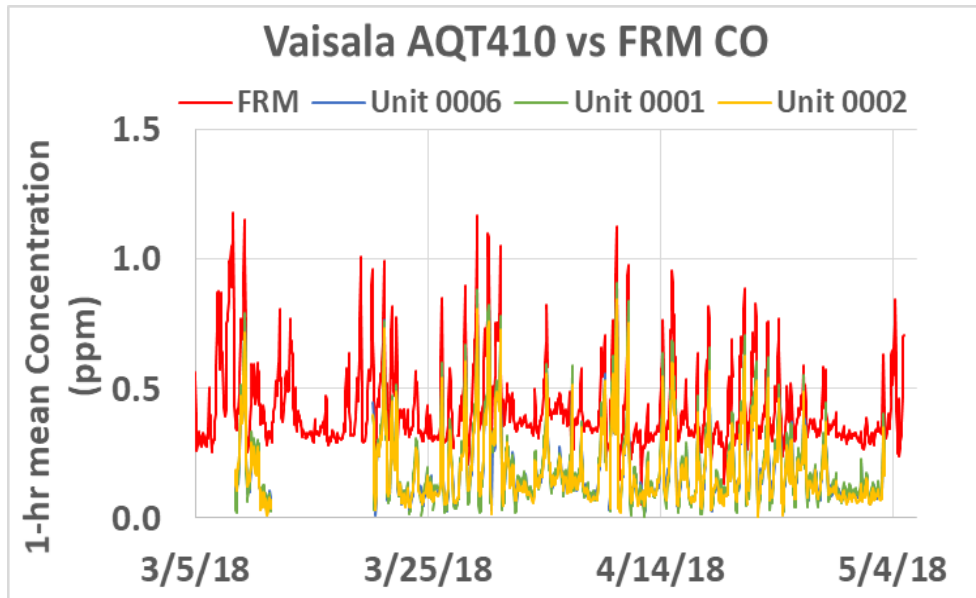


Vaisala AQT410 vs FRM (NO₂; 1-hr mean)

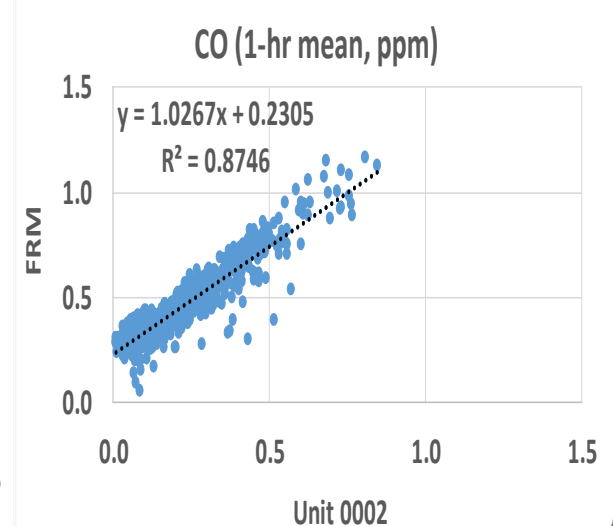
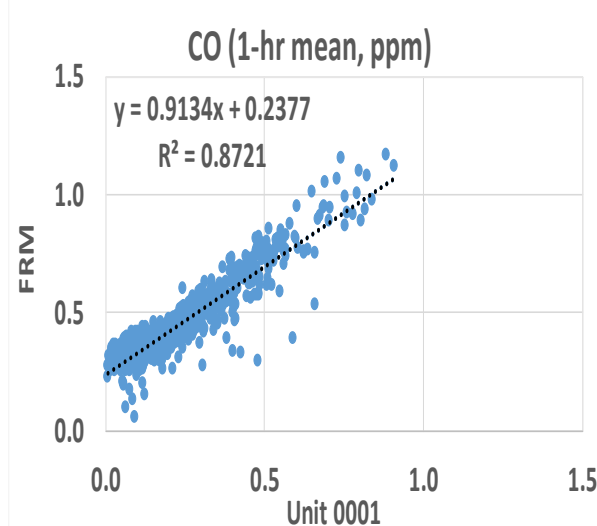
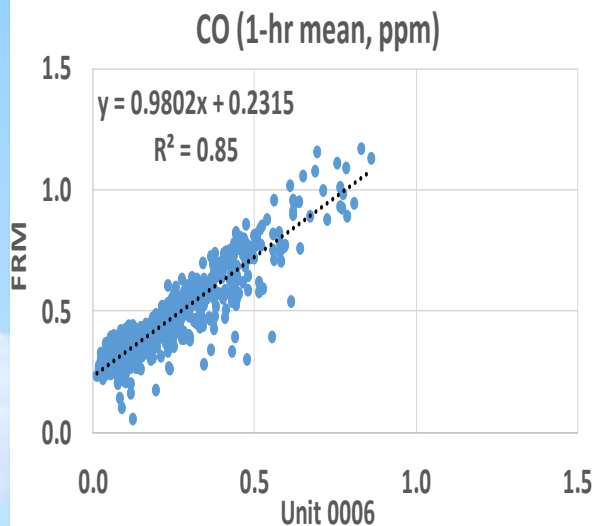
- NO₂ measurements from all three AQT410 sensors correlate moderately with the corresponding FRM data ($0.44 < R^2 < 0.63$) and overall, they overestimate NO₂ concentrations measured by the FRM instrument



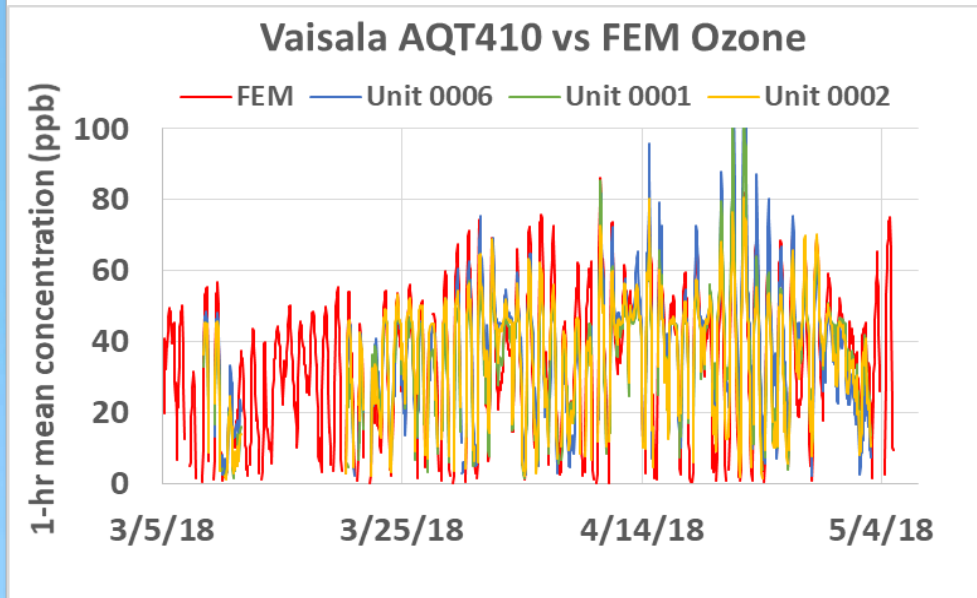
Vaisala AQT410 vs FRM (CO; 1-hr mean)



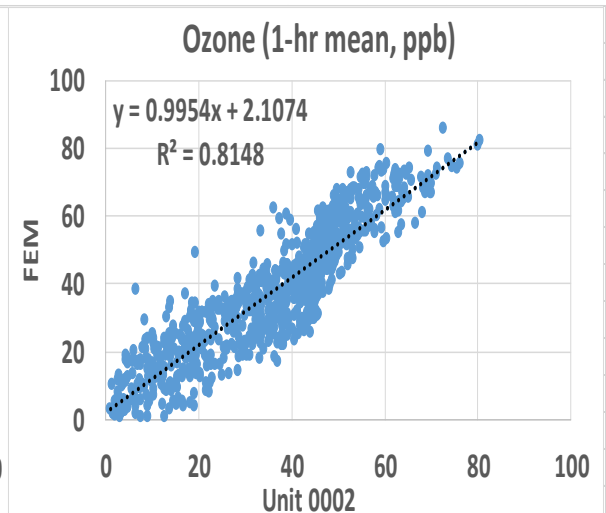
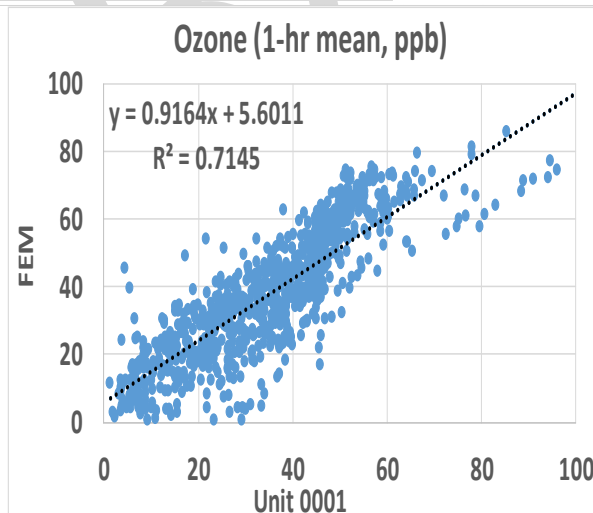
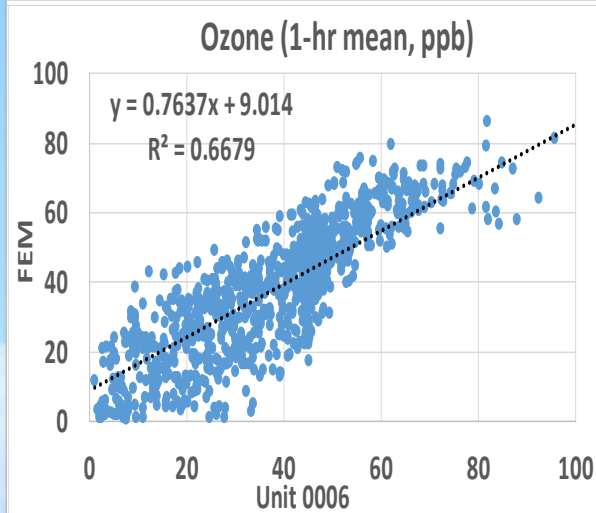
- AQT410 sensors show very good correlations with the corresponding FRM CO data ($0.85 < R^2 < 0.88$)
- AQT410 sensors seem to track well the diurnal CO variation recorded by the FRM instrument



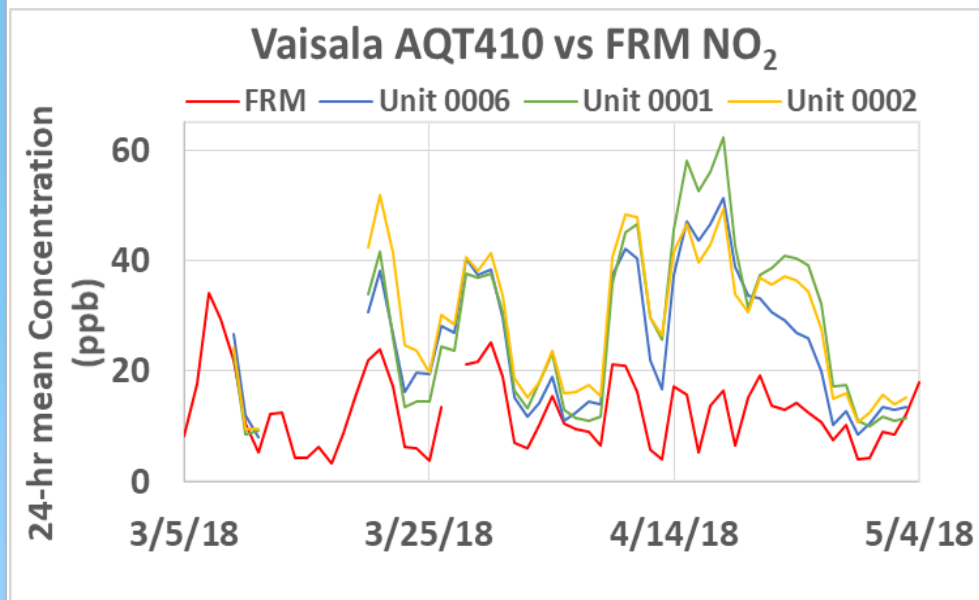
Vaisala AQT410 vs FEM (Ozone; 1-hr mean)



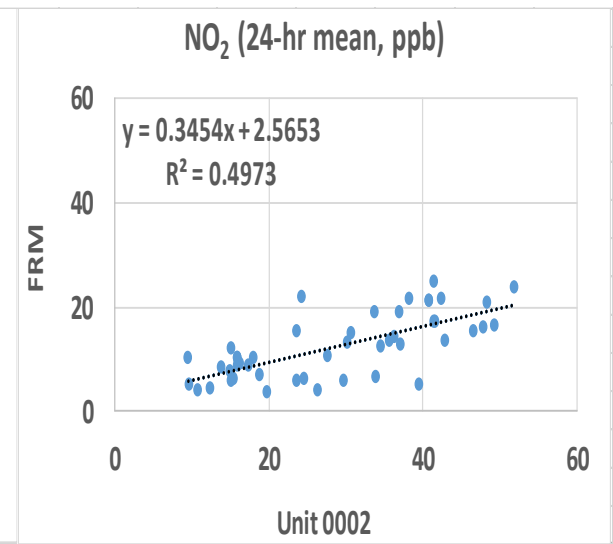
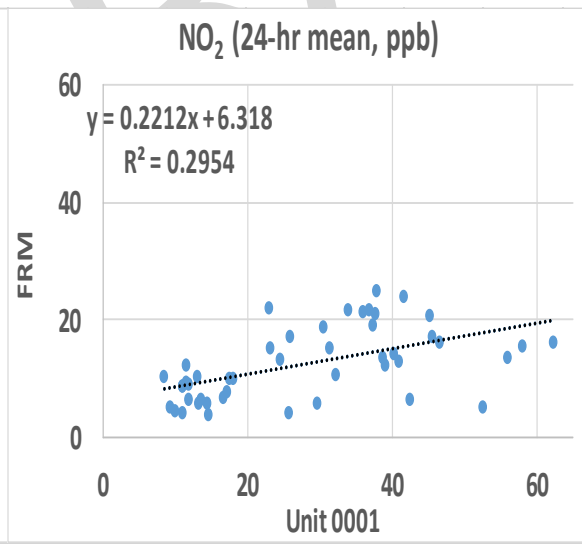
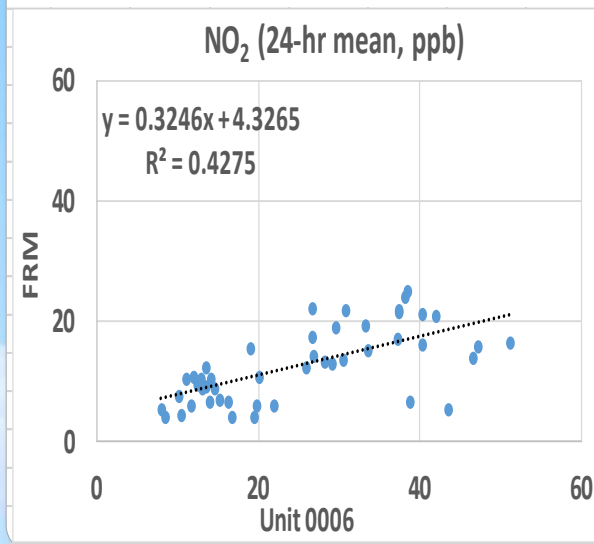
- AQT410 O_3 measurements show good correlations with the corresponding FEM data ($0.66 < R^2 < 0.82$)
- AQT410 track well the diurnal O_3 variations recorded by the FEM instrument



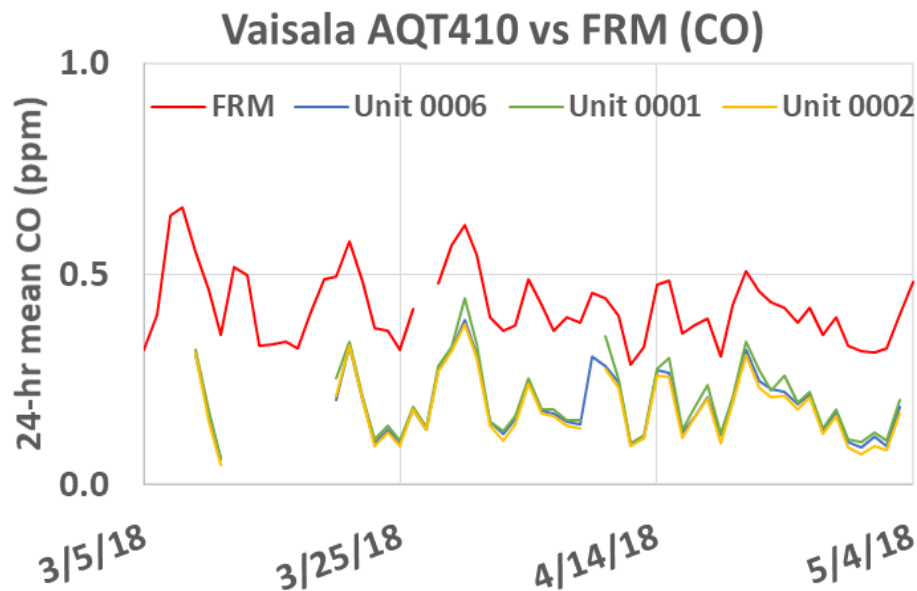
Vaisala AQT410 vs FRM (NO₂; 24-hr mean)



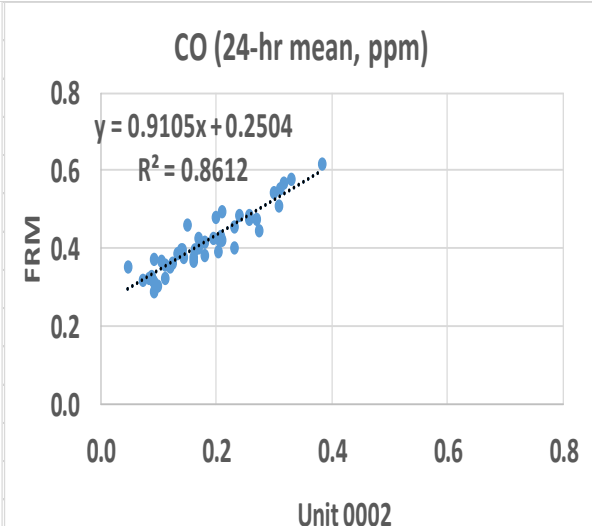
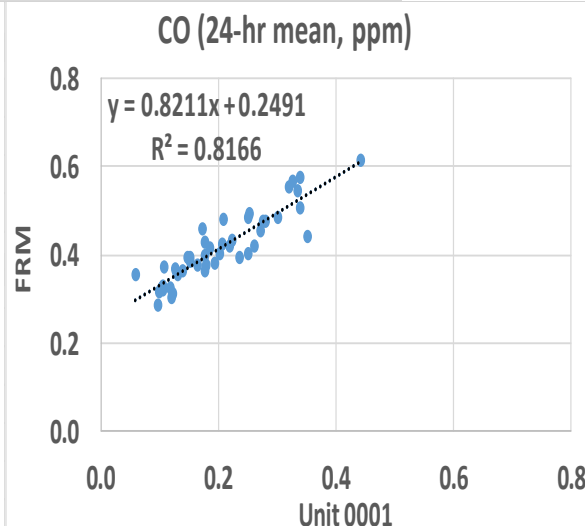
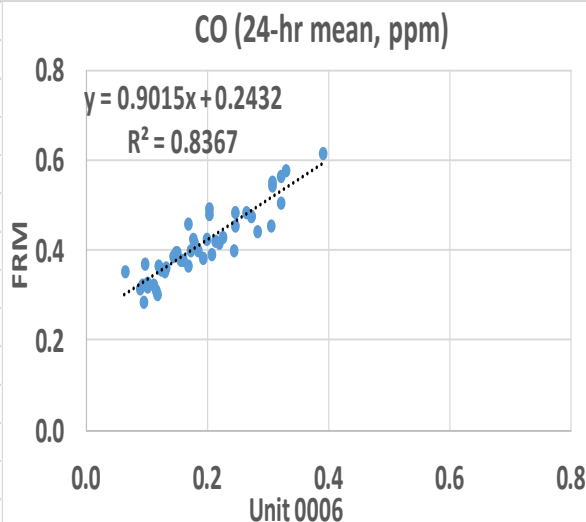
- NO₂ measurements from all three AQT410 sensors correlate moderately with the corresponding FRM data ($0.29 < R^2 < 0.50$) and overall, they overestimate NO₂ concentrations measured by the FRM instrument



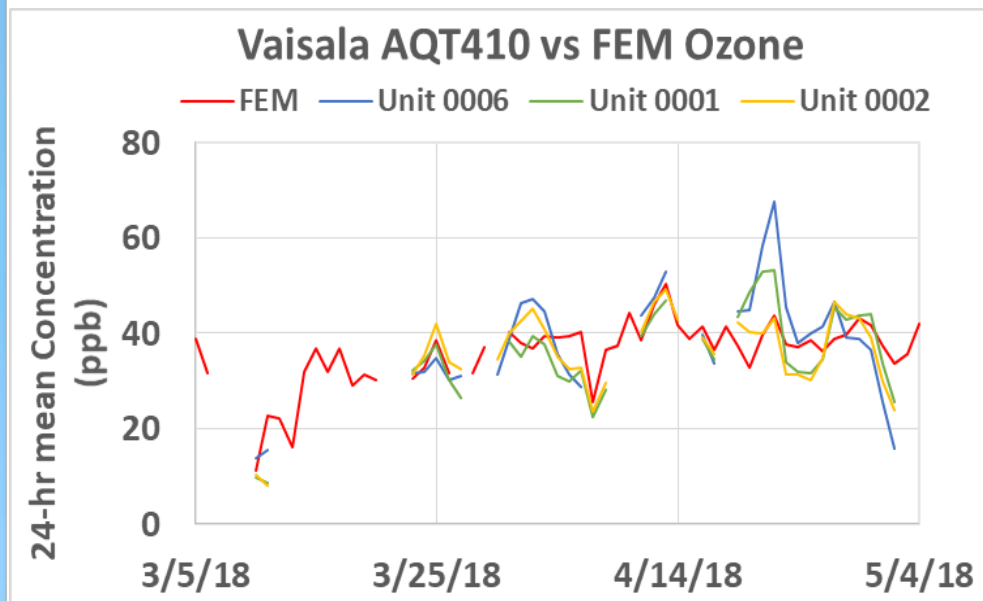
Vaisala AQT410 vs FRM (CO; 24-hr mean)



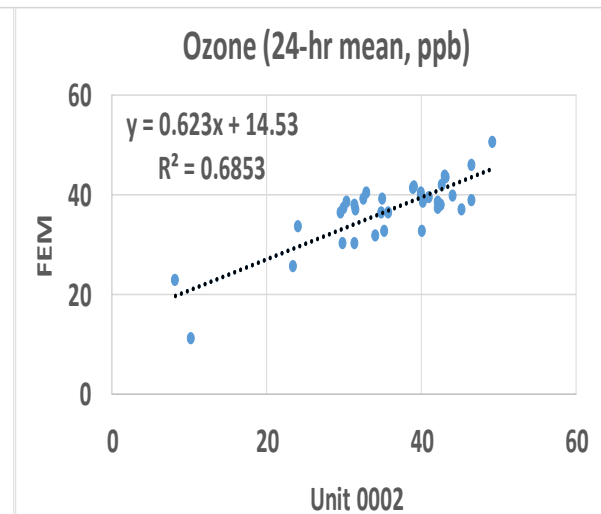
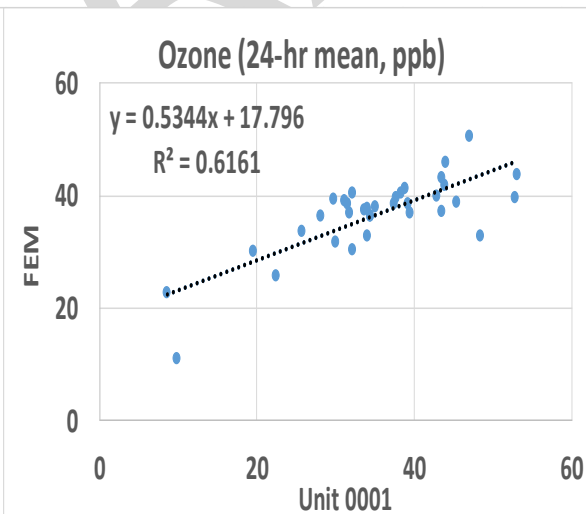
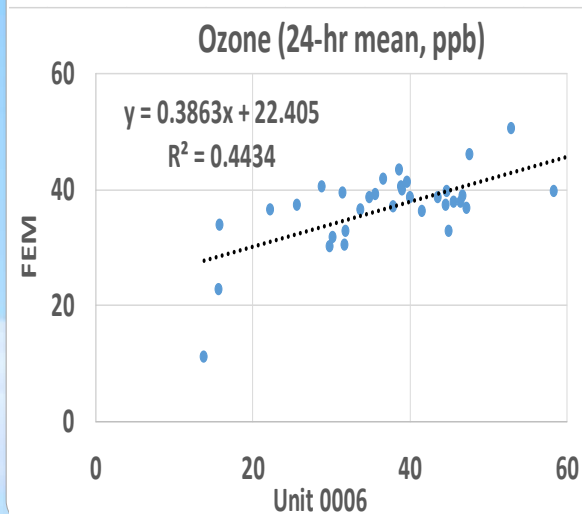
- AQT410 sensors show very good correlations with the corresponding FRM CO data ($0.81 < R^2 < 0.87$)
- AQT410 sensors seem to track well the CO variation recorded by the FRM instrument



Vaisala AQT410 vs FEM (Ozone; 24-hr mean)



- AQT410 O₃ measurements show moderate correlations with the corresponding FEM data ($0.44 < R^2 < 0.69$)



Discussion

- Overall, the three Vaisala AQT410 v.1.15 devices, each measuring NO₂, CO and O₃, showed a high data recovery (>96%), except for O₃ measurements which showed 85% data recovery
- AQT410 v.1.15 sensors showed low intra-model variability for CO and O₃ and moderate intra-model variability for NO₂
- CO concentrations measured by AQT410 v.1.15 sensors demonstrated good correlations with the corresponding FRM data ($R^2 > 0.8$) for all 5-min, 1-hr and 24-hr averages. Ozone showed good correlations with the corresponding FEM data ($R^2 > 0.65$) for 5-min, 1-hr and 24-hr averages with the exception of the Unit 0006 24-hr averages which showed a moderate correlation ($R^2 > 0.4$)
- NO₂ showed moderate correlations ($R^2 > 0.43$, except for 24-hr average for Unit 0001)
- Temperature and relative humidity measured by AQT410 v.1.15 sensors correlated very well ($R^2 > 0.97$) with the corresponding values collected using a substantially more expensive meteorological instrument and were quite accurate
- It should be noted that no sensor calibration had been performed by SCAQMD Staff prior to the beginning of this field testing
- Laboratory chamber testing under temperature- and relative humidity- controlled conditions, known individual gas concentrations and known concentrations of interferent gas mixtures may be necessary to fully evaluate the performance of the Vaisala AQT410 v.1.15 sensors
- All results are still preliminary